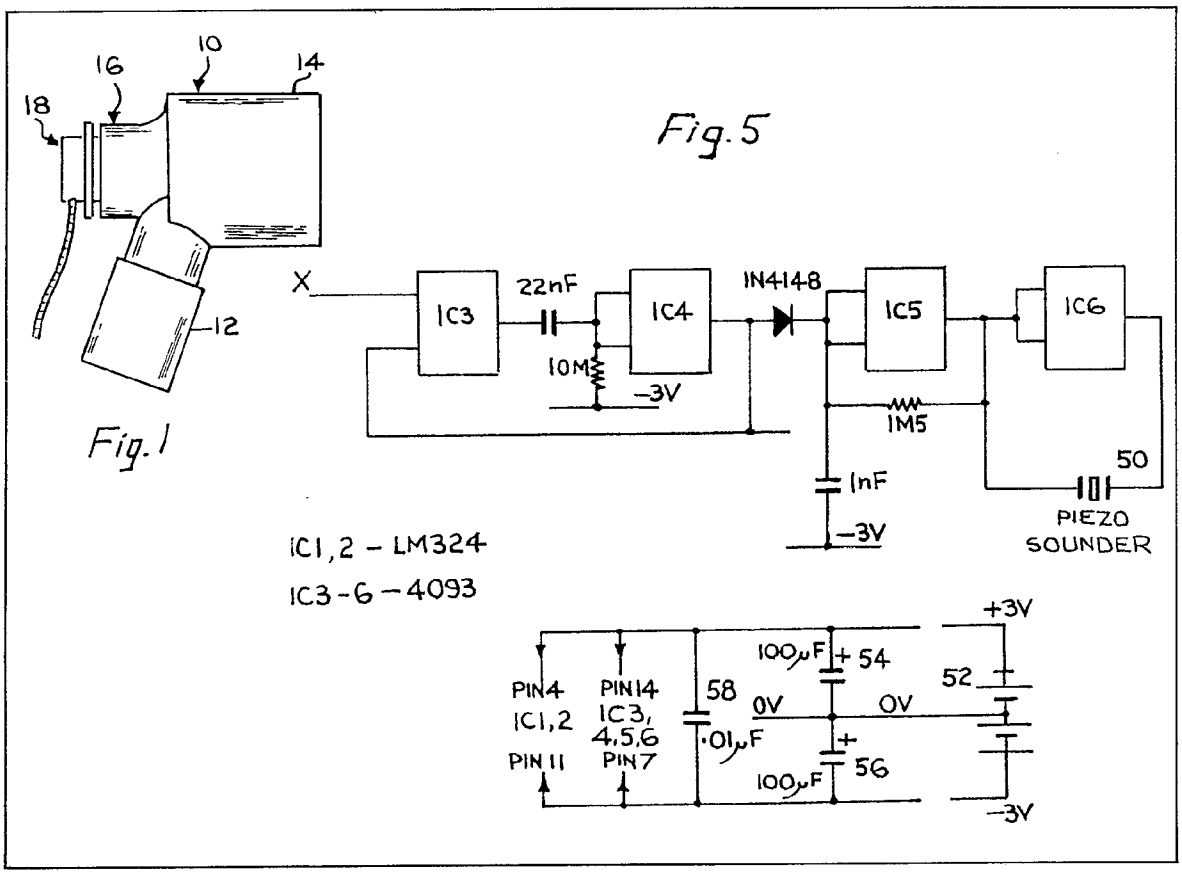
(12) UK Patent Application (19) GB (11) 2 127 299 A

(21) Application No **8324365**
(22) Date of filing **12 Sep 1983**
(30) Priority data
(31) **8226937**
(32) **21 Sep 1982**
(33) **United Kingdom (GB)**
(43) Application published **11 Apr 1984**
(51) **INT CL³** **A61M 17/00**
(52) Domestic classification **A5T** ED **G1N** 19B2Q 19D10 19X5 30P5 ENR **G4N** 1CX 3A 5A 6E CA **U1S** 1026 1046 A5T G1N G4N
(56) Documents cited **GB A 2046969** **GB A 2039741** **GB 1568808** **EP A1 0024327** **US 3316902**
(58) Field of search **A5T** **G1N**

(71) Applicant **Simon Ashby, 34 Caraway Road, Fulbourn, Cambridgeshire CB1 5DU.**
(72) Inventor **Simon Ashby**
(74) Agent and/or Address for Service **Keith W. Nash & Co., 90-92 Regent Street, Cambridge CB2 1DP.**

(54) Improvements in and relating to respiratory monitoring

(57) A method and device for monitoring breathing during anaesthesia effected by supplying an air/gas mixture through a pipeline to a subject, wherein an elbow fitting (10) is connected in the pipeline, said fitting carrying a probe (18) locating at the axial centre of the elbow a temperature sensitive, current carrying element (28) which forms a semiconductor junction in an electrical defection circuit which responds to change in the electrical characteristics of the junction to produce an output signal having a magnitude which varies in sympathy with temperature variations at said junction.



GB 2 127 299 A

2127299

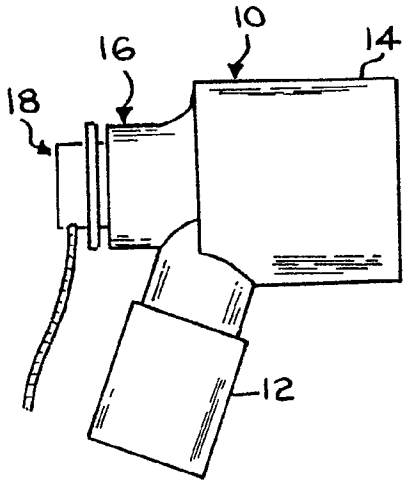


Fig.1

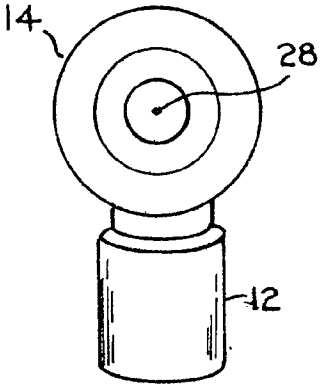


Fig.2

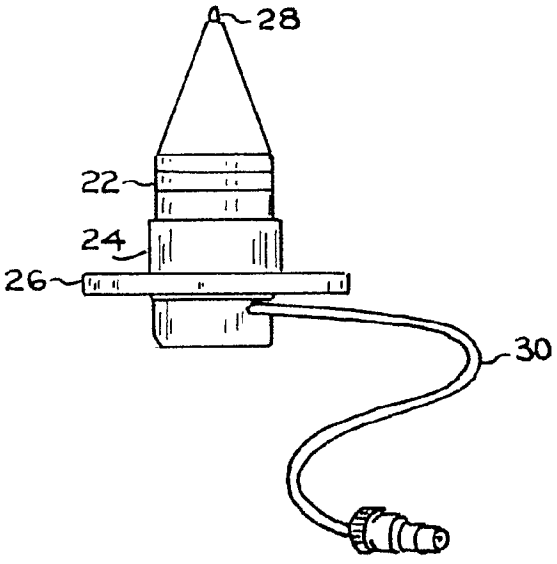


Fig.3

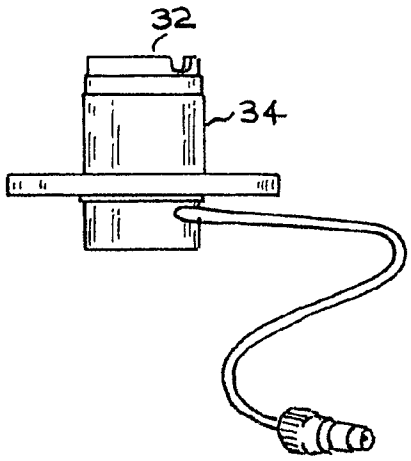


Fig.4

2127299

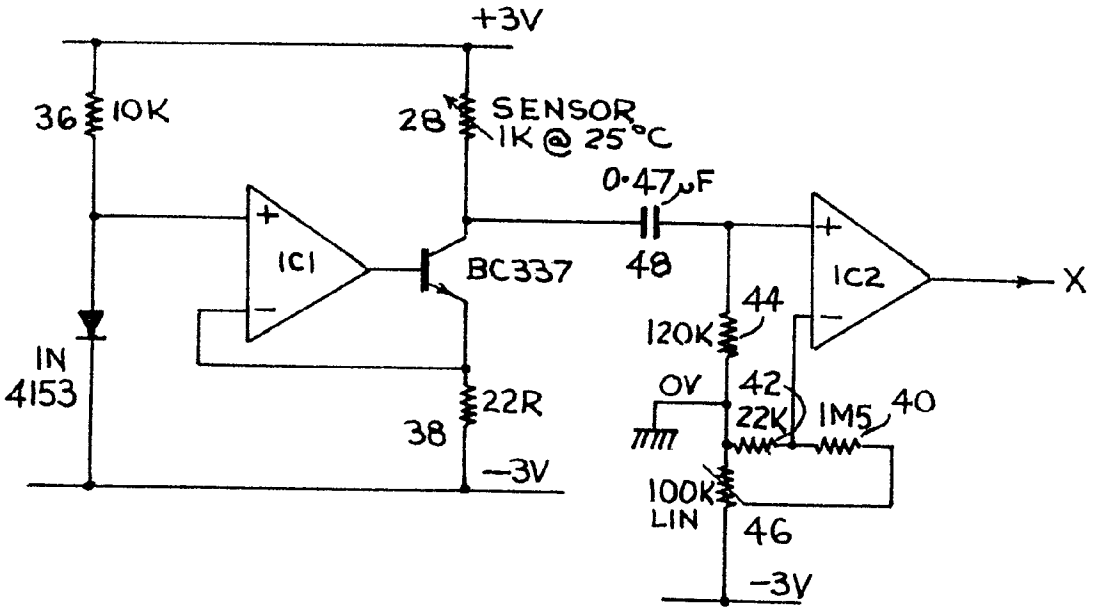
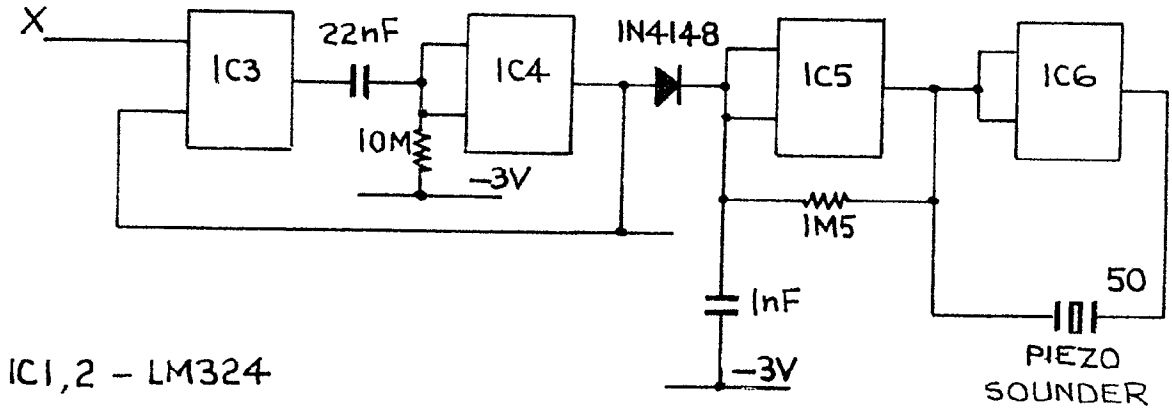
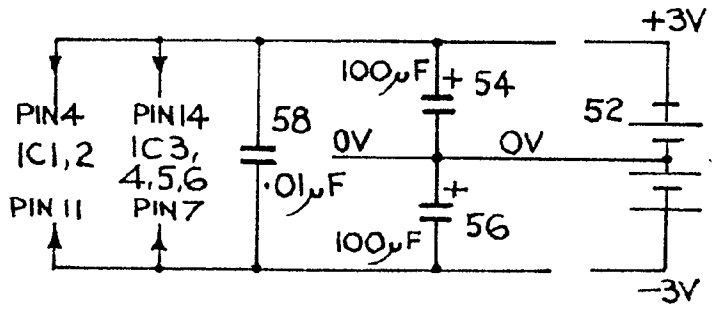


Fig. 5



IC1,2 – LM324

IC3-6 – 4093



SPECIFICATION

Improvements in and relating to respiratory monitoring

Field of the invention

This invention concerns respiratory monitoring and in particular a device which can be incorporated into the air-gas supply to an anaesthetised subject to provide an immediate indication of respiratory failure.

The invention may be utilised on any anaesthetised subject whether human or animal but is of particular application in the veterinary field where operations often have to be carried out single handed by the veterinary surgeon.

Background to the invention

In veterinary work it has hitherto been commonplace to monitor the heartbeat of an anaesthetised animal but this is not always satisfactory. In the event of heart failure in a small animal in particular, it is very difficult to apply corrective treatment to revive the failed heart muscles and the heart monitoring that has often been used in operations on small animals can only indicate, in the event of heart failure, that there is no point in proceeding with the operation. Thus whilst such monitoring is relevant to operations on large and valuable animals, heart monitoring during operations on small animals such as domestic pets can be of minimal value.

It is an object of the present invention to provide a device which will indicate respiratory failure and which can be expanded to give advance warning of respiratory breakdown of an anaesthetised subject.

An advantage of this approach is that respiratory failure can usually be corrected before heart failure occurs and in this event there is minimal if any brain damage, whereas in a small animal, heart failure for even a short time can result in serious brain damage.

Although described so far in relation to small animal operations in veterinary work, it will be appreciated that the invention could have considerable uses in the subject of anaesthesia since such a device will monitor the breathing of the anaesthetised person and will warn the anaesthetist immediately of any respiratory breakdown, thus relieving some of the concentrated monitoring required by the anaesthetist during a long operation.

Summary of the invention

According to one aspect of the invention a respiratory monitoring device, for use during anaesthesia, wherein a mixture of air and gas is supplied along a pipeline to a sleeping subject, typically during an operation, to maintain the sleeping state (all known per se), comprises:

(1) a temperature sensitive semiconductor junction having small thermal inertia

(2) means mounting the junction to the pipeline used to connect the subject and the gas/air supply used, and

(3) electric circuit means responsive to change in the electrical characteristics of the junction brought about by changes of temperature to produce an electrical output signal at least one parameter of which varies in sympathy with variations in temperature of the junction.

"Small thermal inertia" in this context is intended to mean that the temperature of the junction will follow changes in temperature of the immediate environment very rapidly.

By subjecting such a junction to the passage of air/gas mixture as it flows to and from the anaesthetised subject, so the cooling effect of the passage of the air/gas mixture (whether being inhaled or exhaled) will cause the junction temperature to momentarily drop in response to each air/gas mixture movement and provided the sensitivity of the electric circuit means is sufficient, so the electrical signal parameter will likewise vary at each inhalation and exhalation.

According to a preferred feature of the invention the junction is mounted in an elbow bend in the pipeline.

According to a further preferred feature of the invention the junction is located in a sleeve which extends into the pipeline so as to shield the junction from direct impingement by the air/gas flow through the pipeline when flowing in one direction whilst leaving the junction fully exposed to the air/gas flow when flowing in the opposite direction. In this way the parameter of the electrical signal which varies with air/gas flow will vary by a greater extent when the flow is in the said opposite direction than when the flow is in the said one direction. By employing a constraint which distinguishes between the parameter value corresponding to the flow in the one direction and the value corresponding to the flow in the opposite direction, so an output signal can be obtained having a parameter which varies only once with each complete respiration cycle of the anaesthetised subject.

Preferably the junction is protected from the incoming air/gas flow (i.e. during each inhalation) but *is* exposed to direct impingement of the exhaled air/gas mixture so that the output signal parameter produces a measurable variation only with each exhalation.

It will be seen that in this arrangement any interruption in the exhalation of the subject would be revealed by the failure of the output signal parameter to register a change of value commensurate with an exhalation.

According to a further feature of the invention audible or visual, or both, indicator means may be provided, responsive to the electrical output signal to produce a regularly occurring signal whilst the subject continues to exhale reliably. Any interruption in the subject's exhalation will result in an immediate interruption in the regularly occurring cycle which will immediately draw the attention of the surgeon or anaesthetist to the failing breathing of the subject.

In addition or alternatively circuit means and further alarm means may be provided responsive to an interruption in the exhalation of the subject. By incorporating such an alarm means it is not necessary to provide a regularly occurring indication during the operation (which can be a distraction) but

instead the warning signal is only generated if the anaesthetised subject suddenly ceases to exhale or if the breathing slows below a given rate.

The electrical circuit and indicator may be incorporated into the semi conductor junction support or in a separate housing connected to the junction by way of a flexible conductor.

The invention thus also comprises an improved apparatus for administering air and/or gas to anaesthetise an animal or a human subject for surgery, which includes a source of gas and/or air, a mask or other device for supplying the air/gas mixture to the subject, flexible pipeline means between the said source and the said mask or other device, a semiconductor junction located in said pipeline means or said mask which junction changes its electrical properties in response to a change in temperature of its immediate environment, and circuit means for generating an electrical signal which varies with variations of temperature of the junction with the passage of air past the junction, and means responsive to the electrical signal to produce an alarm indicator in the event of the failure of the breathing of the anaesthetised subject.

The invention also provides a method of monitoring the breathing of an anaesthetised subject (animal or human) comprising the steps of supplying the anaesthetising gas or air/gas mixture via a pipeline containing a semiconductor junction whose electrical characteristics vary in sympathy with the temperature of the immediate environs, and generating an electrical signal to indicate an interruption in the generation of the said signal, thereby indicating if an interruption occurs in the subject's breathing.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side elevation of a unit incorporating a sensor for use in the gas/air mixture supply line to an anaesthetised animal or human being.

Figure 2 is a front elevation to a different scale of a sensor probe as fitted in the device of Figure 1.

Figure 3 is a side elevation to a different scale of a sensor probe as fitted in the device of Figure 1.

Figure 4 is a similar side elevation again to a different scale of another sensor probe as may be fitted in the device of Figure 1.

Figure 5 is a circuit diagram of a complete system embodying the invention.

Detailed description of the drawings

Figure 1 shows an angled pipeline connector 10 adapted to receive air and gas mixture from a source (not shown) through an inlet 12 to supply the mixture via an outlet 14. The bend includes a probe receiving sleeve 15 at the crown of the bend into which is fitted a probe generally designated 18.

Figure 3 shows one probe type which can be fitted into the sleeve 16, which comprises a conical tapering section 20 which protrudes from a cylindrical section 12 which itself is held captive in a cylindrical sleeve 24 around which extends an annular flange 26. At the apex of the conical section 20 is a semiconductor junction 28 which serves to detect changes of temperature in the immediate vicinity of the probe. A flexible cable 30 allows the junction to be connected into a suitable circuit (not shown) by means of a connector 32.

The cylindrical sleeve is conveniently a tight pushfit in the sleeve (6) of the angled bend 10. Alternatively a threaded connection may be used between members 24 and 16 or the two members may be glued or otherwise secured together.

The axial length of the probe 18 is arranged to be such that the detector junction 28 is positioned in the centre of the cross section of the passage through the bend so that any movement of air through the bend will influence the detector temperature. This arrangement will cause an electrical change in the detector function with each passage of air through the bend, i.e. when the subject breathes in as well as when it breathes out.

Figure 4 shows an alternative probe, in which the junction 28 is mounted just below the open end 32 of a cylindrical sleeve 34. The axial placement of the junction 28 is less advanced than that of the junction 28 in the probe of Figure 3 and the shrouding of the junction 28 by the sleeve 34 can be used to advantage. Not only is the probe more protected against damage but when located in the bend shown in Figure 1, the sleeve 34 will shroud and shelter the junction 28 from "gas" moving from the inlet 12 to the outlet 14 of the bend 10 (i.e. during inhalation) but leaves the junction fully exposed to "gas" moving in the opposite direction, so that the net result is that the probe will produce a large response to an exhalation "gas" flow but only a very small (if any) response to inhalation "gas" flow.

Figure 5 is a circuit diagram. The junction 28 is designated by the same reference numeral and is shown as a temperature variable resistor forming a load for a constant current generating circuit made of of ICl, NPN transistor BC337, diode IN4153 and resistors 36 and 38.

Any change in 28 and appears as a voltage signal to IC2 and is compared with an adjustable reference voltage produced by resistors 40, 42 and 44 and potentiometer 46 which is employed to vary the threshold sensitivity of IC2 to resistance (and therefore temperature) variations of the junction 28.

Since only changes in state are required no d.c. path is needed between the BC337 and IC2 and transfer is achieved via a capacitor 48.

A pulse generator comprises the gates IC3, IC4, each of which is typically a type 4o93 and which when triggered switches on the oscillator IC5, IC6 to drive a piezo sounder 50. The potentiometer 46 is adjusted so that each inhalation and exhalation "air" flow produces a "bleep" from the sounder 5, when the probe type is that of Figure 3.

If a Figure 4 type of probe is used the setting of the potentiometer 46 is adjusted so that a "bleep" is obtained for each exhalation "air" flow only.

A power supply is obtained from a battery bank 52 and a pair of series connected capacitors 54, 56, serve to provide a centre tapped power supply. Overall decoupling is obtained using a capacitor 58.

CLAIMS

1. A respiratory monitoring device, for use during anaesthesia, wherein a mixture of air and gas is supplied along a pipeline to a sleeping subject, typically during an operation, to maintain the sleeping state, said monitoring device comprising:

(1) a temperature sensitive semiconductor junction having small thermal inertia;

(2) means mounting the junction to the pipeline used to connect the subject and the gas/air supply, and

(3) electric circuit means responsive to change in the electrical characteristics of the junction brought about by changes of temperature to produce an electrical output signal at least one parameter of which varies in sympathy with variations in temperature of the junction.

2. A device according to claim 1, wherein the junction is mounted at an elbow bend in the pipeline.

3. A device according to claim 1 or claim 2, wherein the junction is located in a sleeve which extends into the pipeline so as to shield the junction from direct impingement by the air/gas flow through the pipeline when flowing in one direction whilst leaving the junction fully exposed to the air/gas flow when flowing in the opposite direction.

4. A device according to claim 3, wherein the sleeve and junction are so arranged that the junction is shielded from gas flow in the direction from the supply to the patient.

5. A device according to any of claims 1 to 4, including an audio and/or visual indicator means responsive to the electrical output signal to produce a regularly occurring signal during regular repetitive gas flows in the direction away from the patient.

6. A device according to any of claims 1 to 5, including an alarm means operable responsive to interruption in regular repetitive gas flows in the direction away from the subject.

7. A device according to any of claims 1 to 6 wherein the said junction comprises a temperature variable resistor connected to an electrode forming part of a constant current generating circuit.

8. A device according to claim 7, wherein change in voltage output from the control current generating circuit is composed with a reference voltage adjustable for variation of threshold sensitivity.

9. A device according to claim 8, wherein the output of the comparator drives a pulse generator for driving a piezo sounder.

10. Apparatus for administering air and/or gas to anaesthetise an animal or a human subject for surgery, which includes a source of gas and/or air, a mask or other device for supplying the air/gas mixture to the subject, flexible pipeline means between the said source and the said mask or other device, a semiconductor junction located in said pipeline means or said mask which junction changes its electrical properties in response to a change in temperature of its immediate environment, and circuit means for generating an electrical signal which varies with variation of temperature of the junction with the passage of air past the junction, and means responsive to the electrical signal to produce an alarm indication in the event of the failure of the breathing of the anaesthetised subject.

11. A method of monitoring the breathing of an anaesthetised subject (animal or human) comprising the steps of supplying the anaesthetising gas or air/gas mixture via a pipeline containing a semiconductor junction whose electrical characteristics vary in sympathy with the temperature of the immediate environs, and generating an electrical signal to indicate an interruption in the generation of said signal, thereby indicating if an interruption occurs in the subject's breathing.

12. A respiratory monitoring device substantially as hereinbefore described with reference to the accompanying drawings.

13. A method of monitoring breathing during anaesthesia substantially as hereinbefore described.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1984.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.